IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANT:	Daniel N. Karpen
SERIAL NO.:	09/096,999
FILED:	July 13, 1998
FOR:	MAGNETICALLY SHIELDED FLUORESCENT BALLAST
GROUP ART UNIT:	2817
EXAMINER:	D. Vu

SECTION 132 DECLARATION

I, Daniel Karpen, PE hereby declare:

I am the above named applicant and the inventor of the subject matter of the above-identified patent application.

My background is as follows:

I am a licensed professional engineer with over twenty years experience in lighting design.

I make this Declaration to demonstrate that United States Patent Number 5,446,617 of Blocher does not teach shielding the magnetic component of an electromagnetic field.

Blocher states at column 1, lines 29 to 33 that ballasts should be shielded to prevent radio frequency interference (RFI) and electro-magnetic interference (EMI).

The decision of the USPTO Board of Patent Appeals and Interferences, in its Decision of March 24, 2003, stated at page 6, line 17 through page 7, line 3 as follows:

> "While it is true that Blocher describes housing 10 (Fig.1) as being electrically grounded (via grounding wires 50; Fig.3) the reference is clear that housing 10 also serves as magnetic shielding. The enclosure and grounding structure decreases transmission of radio frequency interference (RFI) and electro-magnetic interference (EMI), Col. 1, II, 6-16"

With all due respect, the Board of Appeals and Interferences is incorrect. For example, aluminum, which is used in the housing enclosure material of Blocher '617, will not act as magnetic shielding. It is very well known that the only materials that can act as magnetic shielding materials are iron, nickel, cobalt, and in particular alloys made from these metallic elements. These alloys form so-called "soft ferromagnetic alloys", which in comparison to hard magnetic alloys, do not retain their magnetization when a magnetic field is applied to then.

Shielding electro-magnetic interferences is not the same as shielding the magnetic component of electromagnetic fields.

Since Blocher '617 does not magnetically shield against the magnetic component of electro-magnetic fields, only against electro-magnetic interference, it is not enabling of

the disclosure of the claimed present invention and does not solve the long-felt need to shield fluorescent ballasts from the magnetic component of electromagnetic fields. As noted before, Blocher can only shield from electro-magnetic interference (EMI), not from the magnetic component of electromagnetic fields.

In fact, Blocher, having a ballast enclosure made of aluminum, can shield electro-magnetic interference, but cannot shield from exposure to low-frequency magnetic fields, such as the magnetic component of electromagnetic fields. See the enclosed excerpt at page 1182 of Chapter 109 entitled "Grounding and Shielding" of Dorf, *The Engineering Handbook,* CRC Press, IEEE Press,, 1996, pp 1176-1185, as cited previously in Applicant's 131 and 132 Declaration of July 29, 1999.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Daniel Karpen

Dated: May 23, 2003

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RICHARD C. DORF
University of California, Davis

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109

Grounding and Shielding

William G. Duff
Computer Sciences Corporation

Grounding and shielding are two very important factors that must be considered during the design of electronic circuits. Current trends in the electronics industry (such as increases in the number of electronic equipments, reliance on electronic devices in critical applications, higher clock frequencies of computing devices, higher power levels, lower sensitivities, increased packaging densities, use of plastics, etc.) will tend to create more electromagnetic interference (EMI) problems. To avoid problems, EMI control measures must be incorporated into circuit design.

109.1 Grounding[1]

Grounding is one of the least understood and most significant factors in many EMI problems. The primary purposes for grounding circuits, cables, equipments, and systems are to prevent a shock hazard; to protect circuits and equipments; and to reduce EMI due to electromagnetic field, common ground impedance, or other forms of interference coupling. The EMI part of the problem is emphasized in this section.

Characteristics of Ground Conductors

Ideally, a ground conductor should provide a zero-impedance path to all signals for which it serves as a reference. If this were the situation, signal currents from different circuits would return to their respective sources without creating unwanted coupling between circuits. Many interference problems occur because designers treat the ground as ideal and fail to give proper attention to the actual characteristics of the ground conductor.

A commonly encountered situation is that of a ground conductor running along in the proximity of a ground plane as illustrated in Fig. 109.1. The ground conductor and ground plane may be

[1]The material on grounding was adapted from Duff [1989] courtesy of Interference Control Technologies.

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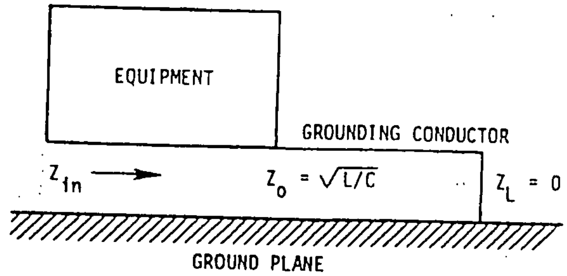


Figure 109.1 Idealized equipment grounding.

represented as a short-circuited transmission line. At low frequencies the resistance of the ground conductor will predominate. At higher frequencies the series inductance and the shunt capacitance to ground will become significant and the ground conductor will exhibit alternating parallel and series resonances as illustrated in Fig. 109.2. To provide a low impedance to ground, it is necessary to keep the length of the grounding conductor short relative to wavelength (i.e., less than 1/20 of the wavelength).

Ground-Related EMI Coupling

Ground-related EMI involves one of two basic coupling mechanisms. The first mechanism results from circuits sharing the ground with other circuits. Figure 109.3 illustrates EMI coupling between culprit and victim circuits via the common-ground impedance. In this case, the interference current (I_{c_g}) flowing through the common-ground impedance (Z_g) will produce an interfering signal voltage (V_i) in the victim circuit. This effect can be reduced by minimizing or eliminating the common-ground impedance.

The second EMI coupling mechanism involving ground is a radiated mechanism whereby the ground loop, as shown in Fig. 109.4, acts as a receiving or transmitting antenna. For this EMI coupling mechanism the induced EMI voltage (for the susceptibility case) or the emitted EMI field

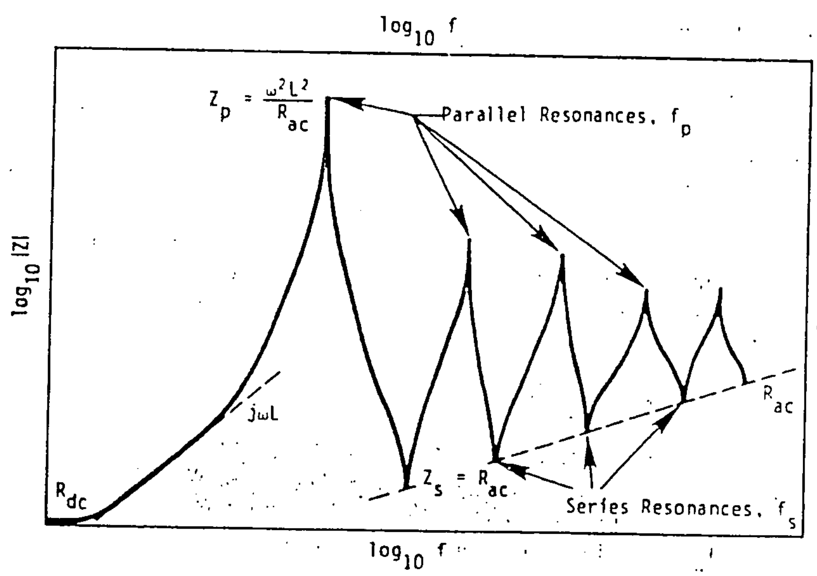
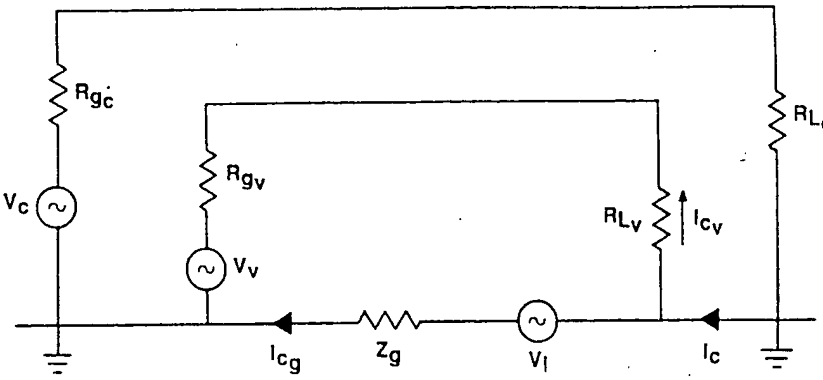


Figure 109.2 Typical impedance versus frequency behavior of a grounding conductor.



$$Z_g << R_{g_V} + R_{L_V}$$

$$\therefore\ I_{c_V} << I_{c_g}\ \&\ I_{c_g} \simeq I_c$$

Figure 109.3 Common-ground impedance coupling between circuits.

(for the emission case) is a function of the EMI driving function (field strength, voltage or current), the geometry and dimensions of the ground loop, and the frequency of the EMI signal. Radiated effects can be minimized by routing conductors close to ground and minimizing the ground-loop area.

It should be noted that both the conducted and radiated EMI coupling mechanisms identified earlier involve a "ground loop." It is important to recognize that ground loop EMI problems can exist without a physical connection to ground. In particular, at RF frequencies, capacitance-to-ground can create a ground loop condition even though circuits or equipments are floated with respect to ground.

Grounding Configurations

A typical electronic equipment may have a number of different types of functional signals as shown in Fig. 109.5. To mitigate interference due to common-ground impedance coupling, as many separate grounds as possible should be used.

The grounding scheme for a collection of circuits within an equipment can assume any one of several configurations. Each of these configurations tends to be optimum under certain conditions and may contribute to EMI problems under other conditions. In general, the ground configurations are a floating ground, a single-point ground, a multiple-point ground, or some hybrid combination.

A floating ground configuration is illustrated in Fig. 109.6. The signal ground is electrically isolated from the equipment ground and other conductive objects. Hence, equipment noise currents present in the equipment and power ground will not be conductively coupled to the signal circuits.

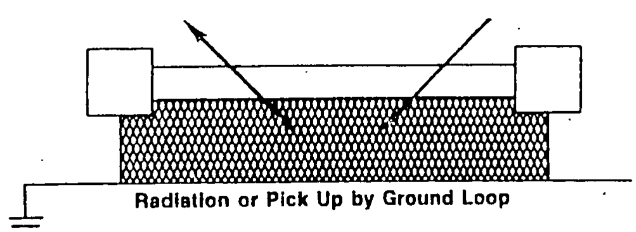


Figure 109.4 Common-mode radiation into and from ground loops.

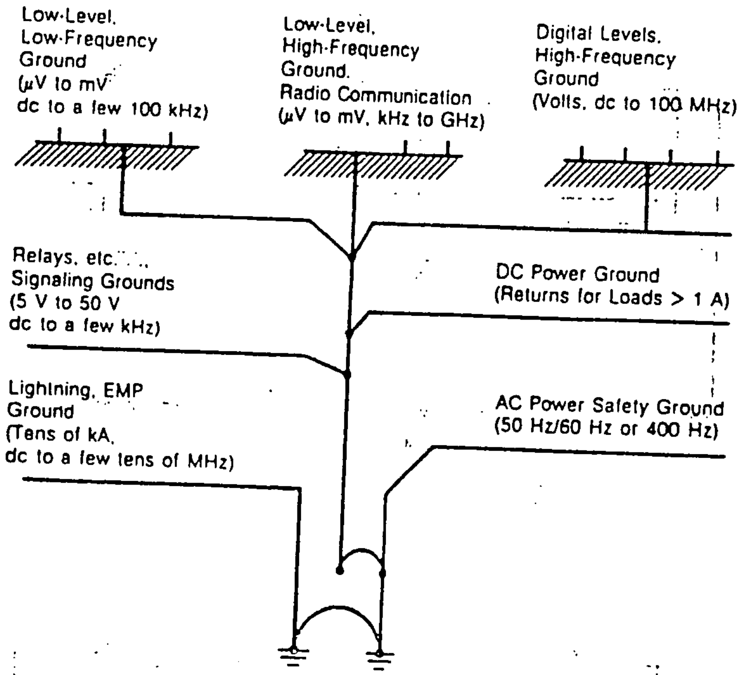


Figure 109.5 Grounding hierarchy.

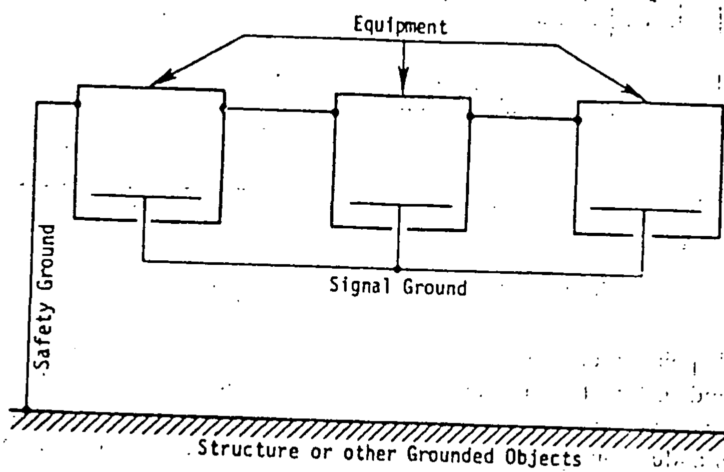


Figure 109.6 Floating signal ground.

The effectiveness of floating ground configurations depends upon their true isolation from other nearby conductors; that is, to be effective, floating ground systems must really float. It is often difficult to achieve and maintain an effective floating system. A floating ground configuration is most practical if only a few circuits are involved and power is supplied from either batteries or DC-to-DC converters.

A single-point ground configuration is illustrated in Fig. 109.7. An important advantage of the single-point configuration is that it helps control conductively coupled interference. As illustrated in Fig. 109.7, EMI currents or voltages in the equipment ground are not conductively coupled into the signal circuits via the signal ground. Therefore, the single-point signal ground network minimizes the effects of any EMI currents that may be flowing in the equipment ground.

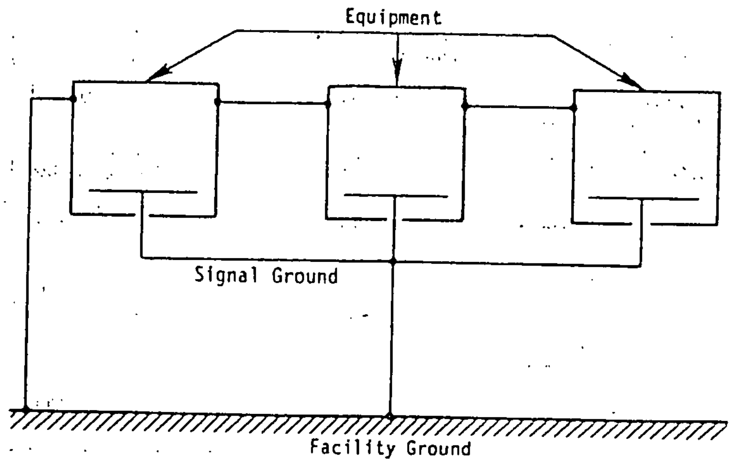


Figure 109.7 Single-point signal ground.

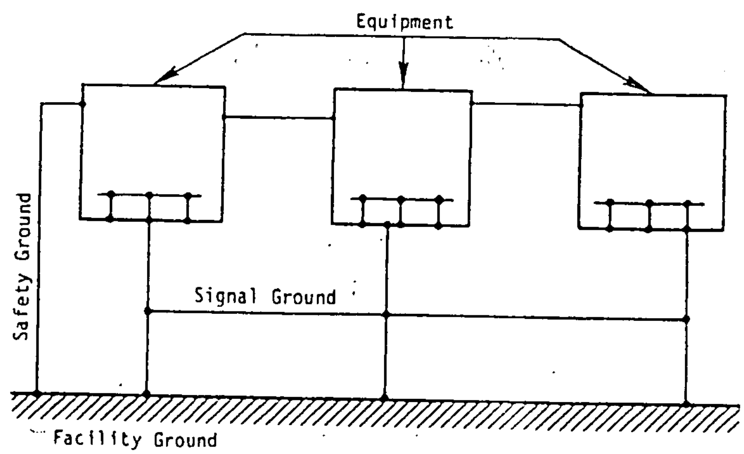


Figure 109.8 Multiple-point ground configuration.

The multiple-point ground illustrated in Fig. 109.8 is the third configuration frequently used for signal grounding. With this configuration, circuits have multiple connections to ground. Thus, in an equipment, numerous parallel paths exist between any two points in the multiple-point ground network. Multipoint grounding is more economical and practical for printed circuits and integrated circuits. Interconnection of these components through wafer risers, mother boards, and so forth should use a hybrid grounding approach in which single-point grounding is used to avoid low-frequency ground loops and/or common-ground impedance coupling; multipoint grounding is used otherwise.

Summary of Grounding Considerations

A properly designed ground configuration is one of the most important engineering elements in protecting against the effects of EMI. The ground configuration should provide effective isolation between power, digital, high-level analog, and low-level analog signals. In designing the ground it is essential to consider the circuit, signal characteristics, equipment, cost, maintenance, and so forth. In general, either floating or single-point grounding is optimum for low-frequency situations and

multiple-point grounding is optimum for high-frequency situations. In many practical applications a hybrid ground approach is employed to achieve the single-point configuration for low frequencies and the multiple-point configuration for high frequencies.

109.2 Shielding[2]

Shielding is one of the most effective methods for controlling radiated EMI effects at the component, circuit, equipment, subsystem, and system levels. The performance of shields is a function of the characteristics of the incident electromagnetic fields. Therefore, shielding considerations in the near-field region of an EMI source may be significantly different from shielding considerations in the far-field region.

Shielding Theory

If a metallic barrier is placed in the path of an electromagnetic field as illustrated in Fig. 109.9, only a portion of the electromagnetic field may be transmitted through the barrier. There are several effects that may occur when the incident wave encounters the barrier. First, a portion of the incident wave may be reflected by the barrier. Second, the portion of the incident wave that is not reflected will penetrate the barrier interface and may experience absorption loss while traversing the barrier. Third, additional reflection may occur at the second barrier interface, where the electromagnetic field exits the barrier. Usually this second reflection is insignificant relative to the other effects that occur and may be neglected.

The shielding effectiveness of the barrier may be defined in terms of the ratio of the impinging field intensity to the exiting field intensity. For high-impedance electromagnetic fields or plane waves, the shielding effectiveness is given by

$$SE_{dB} = 20 \log \left(\frac{E_1}{E_2} \right) \tag{109.1}$$

where E_1 is the impinging field intensity in volts per meter and E_2 is the exiting field intensity in volts per meter. For low-impedance magnetic fields, the shielding effectiveness is defined in terms of the ratio of the magnetic field strengths.

The total shielding effectiveness of a barrier results from the combined effects of reflection loss and absorption loss. Thus, the shielding effectiveness, S, in dB is given by

$$S_{dB} = R_{dB} + A_{dB} + B_{dB} \tag{109.2}$$

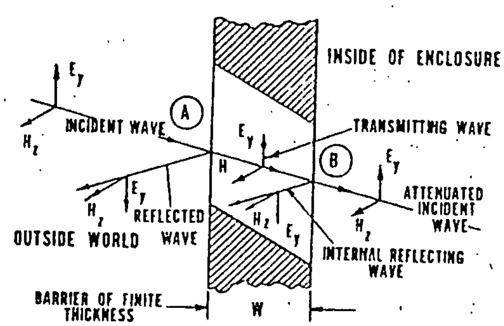


Figure 109.9 Shielding of plane waves.

[2]The material on shielding was adapted from Duff [1991] courtesy of Interference Control Technologies.

where R_{dB} is the reflection loss, A_{dB} is the absorption loss, and B_{dB} is the internal reflection loss. Characteristics of the reflection and absorption loss are discussed in the following sections.

Reflection Loss

When an electromagnetic wave encounters a barrier, a portion of the wave may be reflected. The reflection occurs as a result of a mismatch between the wave impedance and the barrier impedance. The resulting reflection loss, R, is given by

$$\begin{aligned} R_{dB} &= 20\log_{10}\frac{(K+1)^2}{4K}, \qquad K = \frac{Z_w}{Z_b} \\ &\simeq 20\log_{10}\left(\frac{Z_w}{4Z_b}\right), \qquad K \geq 10 \end{aligned} \tag{109.3}$$

where Z_w is the wave impedance $= E/H$, and Z_b is the barrier impedance.

Absorption Loss

When an electromagnetic wave encounters a barrier, a portion of the wave penetrates the barrier. As the wave traverses the barrier, the wave may be reduced as a result of the absorption loss that occurs in the barrier. This absorption loss, A, is independent of the wave impedance and may be expressed as follows:

$$A_{dB} = 8.68t/\delta = 131t\sqrt{f_{MHz}\mu_r\sigma_r} \tag{109.4}$$

where t is the thickness in mm, f_{MHz} is the frequency in MHz, μ_r is the permeability relative to copper, and σ_r is the conductivity relative to copper.

Total Shielding Effectiveness

The total shielding effectiveness resulting from the combined effects of reflection and absorption loss are plotted in Fig. 109.10 for copper and iron materials having thicknesses of 0.025 mm and 0.8 mm, having electric and magnetic fields and plane-wave sources, and having source-to-barrier distances of 2.54 cm and 1 meter.

Shielding Materials

As shown in Fig. 109.10, good shielding efficiency for plane waves or electric (high-impedance) fields is obtained by using materials of high conductivity such as copper and aluminum. However, low-frequency magnetic fields are more difficult to shield because both the reflection and absorption loss of nonmagnetic materials, such as aluminum, may be insignificant. Consequently, to shield against low-frequency magnetic fields, it may be necessary to use magnetic materials.

Conductive Coatings

Conductive coatings applied to nonconductive materials such as plastics will provide some degree of EMI shielding. The principal techniques for metalizing plastic are the following:

- Conductive paints
- Plating (electrolytic)

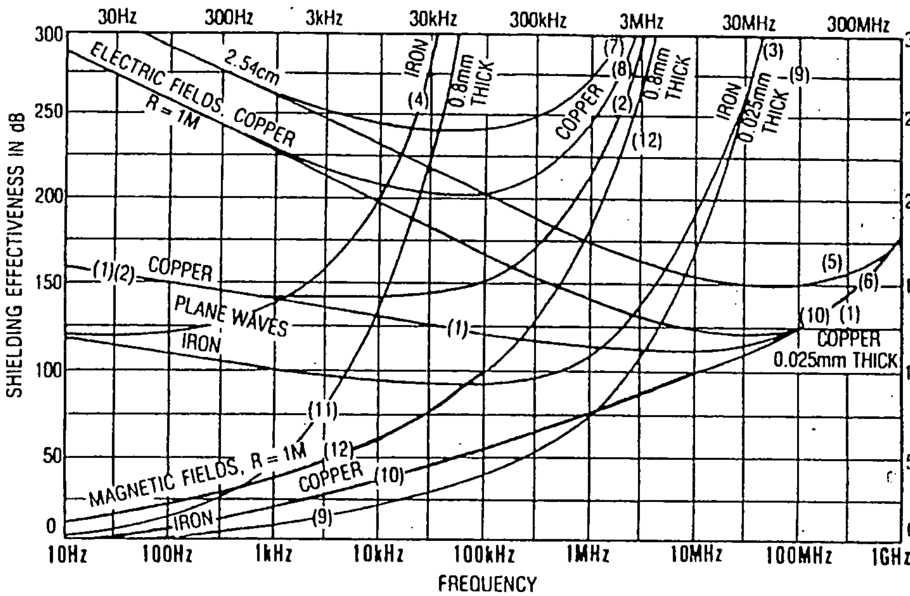


Figure 109.10 Total shielding effectiveness.

- Electroless plating
- Flame spray
- Arc spray
- Ion (plasma torch) spray
- Vacuum deposition

Because the typical conductive coatings provide only a thin film of conductive material, the shielding results from reflection losses that are determined by the ratio of the wave impedance to the conductive barrier impedance. The surface resistance (in ohms per square) will determine shielding effectiveness. Figure 109.11 shows comparative data for shielding effectiveness for various conductive coatings. The most severe situation (i.e., a low-impedance magnetic field source) has been assumed.

Aperture Leakages

Various shielding materials are capable of providing a high degree of shielding effectiveness under somewhat idealized conditions. However, when these materials are used to construct a shielded housing, the resulting enclosure will typically have holes and seams that may severely compromise the overall shielding effectiveness.

Figure 109.12 shows a rectangular aperture in a metal (or metalized) panel. A vertically polarized incident electric field will induce currents in the surface of the conductive panel. If the aperture dimensions are much less than a half wavelength, the path around the slot will provide a low impedance to the induced currents and, as a result, the aperture leakage will be small. On the other hand, as the aperture dimensions approach a half wavelength, the path around the slot will provide a high impedance to the induced currents and the aperture leakage will be significant. An aperture with dimensions equal to or greater than a half wavelength will provide almost no shielding (i.e., the incident field will propagate through the aperture with very little loss). In general, the shielding effectiveness of a conductive panel with an aperture may be approximated by

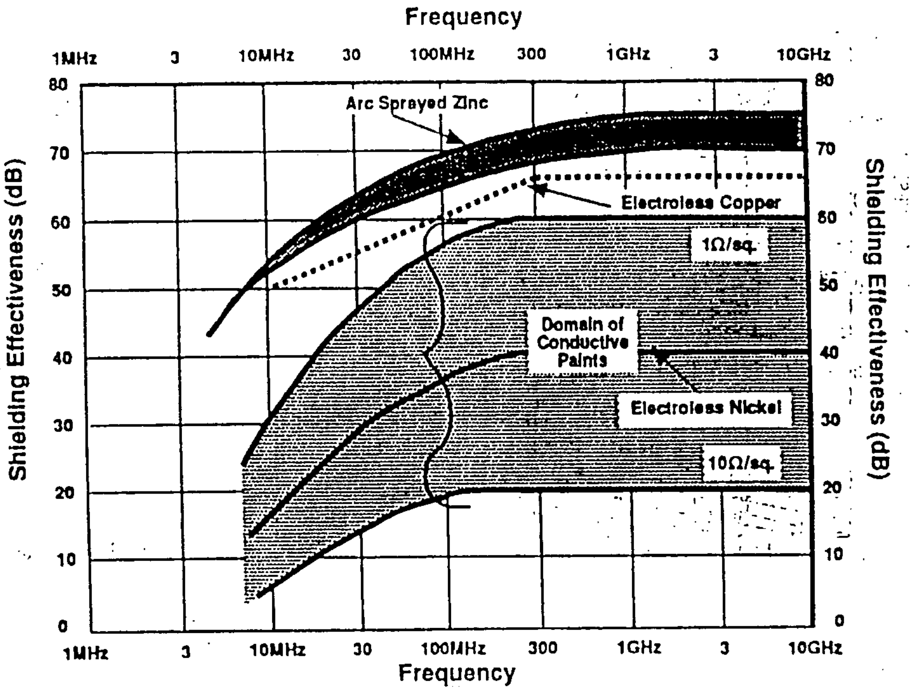


Figure 109.11 Shielding of conductive coatings. (By standard. 30 cm distance test. Near field attenuation is given against H field.) For paints, thickness is typically 2 mil. = .05 mm.

the following equation:

$$SE_{dB} \cong 100 - 20\log L_{mm} \times F_{MHz} + 20\log\left(1 + \ln\frac{L}{S}\right) \tag{109.5}$$

To maintain shielding integrity for an equipment enclosure, it may be necessary to provide EMI protection for the apertures.

Summary of Shielding Considerations

Shielding can provide an effective means of controlling radiated EMI effects. To ensure that shielding effectiveness requirements are met, it is necessary to

- Select a material that is capable of providing the required shielding
- Minimize the size of openings to control aperture leakages

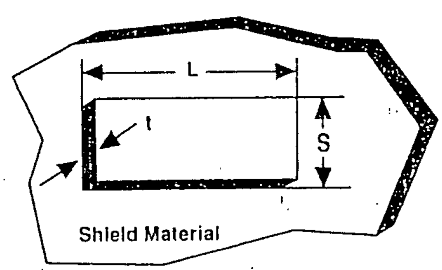


Figure 109.12 Slot and aperture leakage.

- Subdivide large openings into a number of smaller ones
- Protect leaky apertures (e.g., cover with wire screen)
- Use EMI gaskets on leaky seams
- Filter conductors at points where they enter or exit a shielded compartment

Defining Terms

Ground: Any reference conductor that is used for a common return.

Near-field/far-field transition distance: For electrically small radiators (i.e., dimensions ≪ wavelength), the near-field/far-field transition occurs at a distance equal to approximately one sixth of a wavelength from the radiating source.

Plane wave: Far-field electromagnetic wave with an impedance of 377 ohms in air.

Reference: Some object whose potential (often 0 volts with respect to earth or a power supply) is the one to which analog and logic circuits, equipments, and systems can be related or benchmarked.

Return: The low (reference) voltage side of a wire pair (e.g., neutral), outer jacket of a coax, or conductor providing a path for intentional current to get back to the source.

Wavelength: The distance corresponding to a period for the electromagnetic wave spatial variation. Wavelength (meters) = 300/frequency (MHz).

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Duff, W. G. 1991. *Electromagnetic Shielding.* EMC EXPO 91 Symposium Record. Interference Control Technologies, Gainesville, VA.

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Further Information

IEEE Transactions on EMC. Published quarterly by the Institute of Electrical and Electronic Engineers.

IEEE International EMC Symposium Records. Published annually by the Institute of Electrical and Electronic Engineers.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

COPY

APPLICANT:	Daniel Karp n
SERIAL NO.:	09/096,999
FILED:	June 13, 1998
FOR:	Magnetically Shielded Fluorescent Lamp Ballast Case
EXAMINER:	D. Vu
MAILING DATE OF ACTION:	October 28, 1999
GROUP ART UNIT:	2821

SECTION 132 DECLARATION

I, Myron Kahn hereby declare:

I am the Chief Executive Officer of Polarized Lighting International of Tarzana, California, the company which has been producing polarized lighting panels for interior lighting for a period of more than forty years. Thus, I am a long time participant in the lighting industry, and an expert in polarized interior illumination and the problems inherent in many existing interior applications.

I am the inventor of the subject matter of U.S. Patent No. 3,777,128 for a light transmitting polarized panel and U.S. Patent No. 4,796,160 for an integral polarized light panel.

As long ago as the late 1930's, when fluorescent lighting was first used in the United States, I worked in a store with fluorescent lighting. I began to have severe headaches, eyestrain, and eventually was forced to leave the job, because of th lighting conditions I worked under.

After World War II, I worked with Alvin and Mortimer Marks for 15 years to develop a polarizing panel that would "solve" the glare problem, since glare from lighting fixtures accounts for many of the visual problems and visual discomfort experienced by workers in facilities where glare from lighting is unfortunately prevalent.

Our research work developed a commercially viable polarized lighting panel for fluorescent fixtures; these panels have been sold from the early 1960's to the present day, and have been installed in millions of square feet of fluorescent lighting fixtures.

During my years in the lighting industry, I have dealt with fixture manufacturers, manufacturer's representatives, lighting specifiers, lighting designers, architects, engineers, and facilities managers. Most of these have been eager to design and build the perfect lighting system, but few have been knowledgeable about how to go about this and what products to employ.

In regard to the present above-referenced U.S. Patent application, in the almost 50 years I have been in the lighting industry, no one ever mentioned to me the problems of electromagnetic fields from fluorescent lighting.

I have read Mr. Karpen's specification for his invention, and he has come up with a very important development, one that has been overlooked by thousands of lighting practitioners. The research he cites from various respect d authorities (California Institute of Technology

and the Environmental Health Center in Dallas) is persuasive in explaining the damaging effects of 1 ctromagnetism on humans who spend hours in such environments which employ electromagnetic lighting ballasts. In addition to these long term effects, despite the previously unsolved need to correct them, short term effects such as visual discomfort, "dry eye," and other visual problems also persist.

Shielding ballasts will greatly reduce or eliminate the effects of electromagnetic components, for the betterment of the lighted environment.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Myron Kahn

Myron Kahn

Dated: December 29 , 1999

PA1132